U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE Data Center Power Use Efficiency Summary Report

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Prepared by Energetics Incorporated
for the Federal Energy Management Program

FEMP
Federal Energy Management Program

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Overview

While data centers represent only a small fraction of the square footage at DOE sites, they are a large and growing energy consumer. At some sites, growth in data center energy use is expected to at least double overall site energy use. The growth in computing capability is causing an ever increasing demand for energy.

DOE's Federal Energy Management Program (FEMP) and Industrial Technologies Program (ITP) are working with the DOE program offices to develop tools and resources to help sites address the issue of increased data center energy use. Reducing the energy consumption of energy intensive buildings such as data centers is crucial to fulfilling the Energy Independence and Security act of 2007 (EISA) and Executive Order 13423 mandate to reduce facility energy intensity by 30 percent by 2015. Recently, President Obama issued Executive Order 13514, which includes the specific instruction to promote electronic stewardship by "implementing best management practices for energy-efficient management of servers and Federal data centers." The first step to achieving these goals in data centers is to understand current energy consumption.

Survey Description

For the second year in a row, FEMP issued a survey requesting power use data from data centers within the Department of Energy. The survey was directed to those program offices within DOE responsible for the majority of data centers, including the Office of Science, the Office of Environmental Management (EM) and the National Nuclear Security Administration (NNSA).

The survey returned complete information for 49 data centers,[i] up from 41 the previous year. Of the 49 data centers, eleven did not meet the required 100kW power draw specified in the survey instructions, however these data centers are still included in this report's analysis.

The survey requested the following information from each data center:

- Program Office Affiliation
- National Laboratory Affiliation
- Zip Code
- Room ID
- Square Footage
- Have you completed DC Pro?
- Is the data center dedicated?
- Facility Contact
- Function - IT Support, High Performance Computing (HPC) or Other
- Construction or Major Renovation Year
- IT Power Draw (kW)
- Cooling Power (kW)
- UPS Input (kW)
- UPS Output(kW)
- UPS Loss (kW)
- Total Power Draw (kW)
- Is the power data exact or approximate?

Summary

The sample of DOE data centers responding to the survey represents 687,051 square feet and a total power draw of over 85 MW. If all data centers are run 24 hours a day, seven days a week, spending on energy to power DOE's data centers would account for approximately 15 percent of DOE's total electricity bill.[ii]

The chart below shows a summary of efficiency measures for DOE data centers. It includes both weighted and unweighted averages for the Power Effectiveness Use (PUE) and Data Center Infrastructure Efficiency (DCIE) metrics.[iii] The weighted average puts more emphasis on data centers with a greater kW draw.[iv]

Table 1:

Summary of Efficiency Measures	
Unweighted Average DCIE	0.58
Weighted Average DCIE	0.70
Unweighted Average PUE	2.00
Weighted Average PUE	1.44
Watts per SQFT (Total Watts/Total ft2)	124.87

In the 2008 DOE data center survey, the average DCIE was 0.57 and the average weighted DCIE was 0.68. The 2009 data reflects a slight increase in efficiency from 2008 to 2009.

The following charts show the PUE and DCIE of DOE data centers. From left to right, the data centers are in order from smallest kW draw to largest. Scientific computing data centers are colored in red, while IT services data centers are colored in blue. Data centers that did not report their function or perform multiple functions are shaded gray. Bars outlined in black represent dedicated data centers. Figure 1 shows the PUE of each data center.

Figure 1: **PUE of DOE Data Centers**

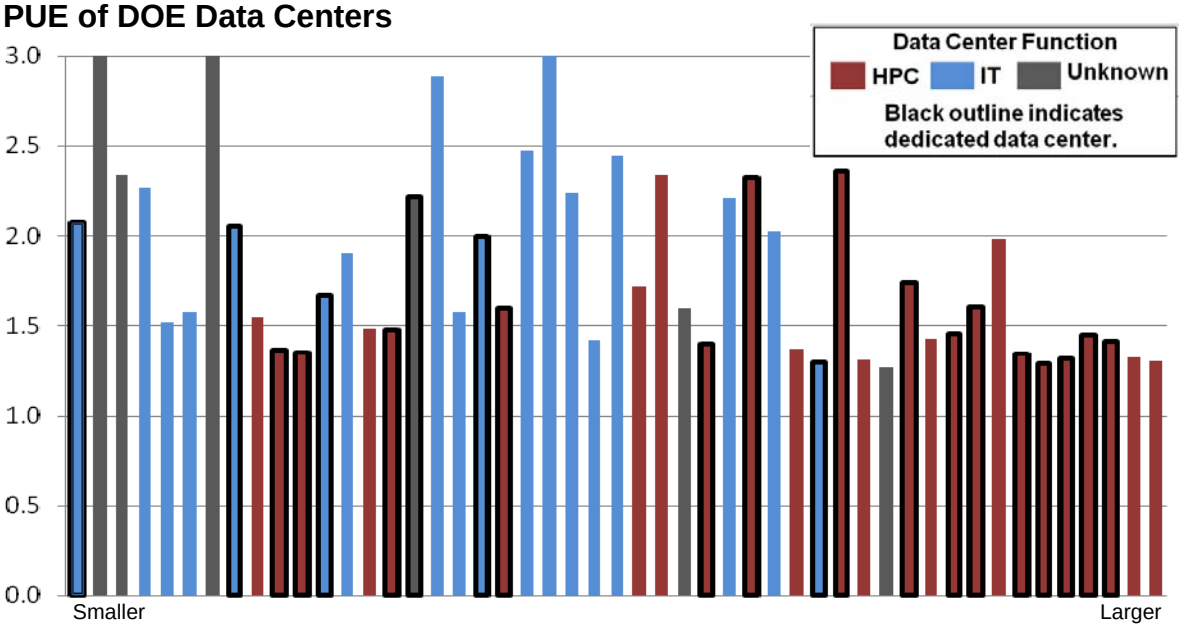
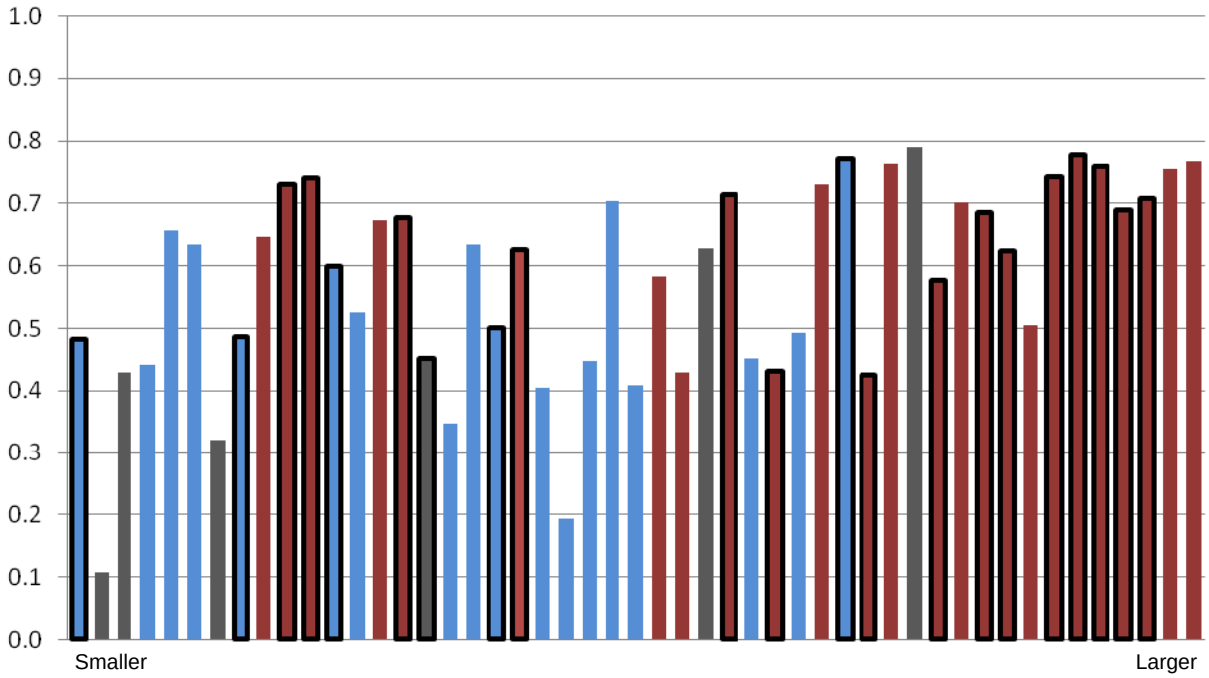


Figure 2, below, shows the data measured by another common infrastructure efficiency measure, the Data Center Infrastructure Efficiency, or DCIE. The DCIE is IT power divided by total power, simply the inverse of PUE. Thus, the closer the DCIE is to 1, the closer the data center is using all of its input power for computing.

Figure 2: DCIE of DOE Data Centers



Data Centers by Size (kW usage)
Data was collect on the total kW usage of each data center. This data ranged from 8.3 kW to 13,997 kW. In Table 2, the data centers are broken into three categories based on their total power draw. The chart shows that data centers in 1001 kW and greater group do tend to be more efficient than the other two groups.

Table 2: Data Center Efficiency by Power Use Category

kW Range	# in Category	Average Unweighted PUE	Average Unweighted DCIE
0-150 kW	14	2.40	0.53
151-1000 kW	16	2.17	0.51
1001+ kW	19	1.56	0.67

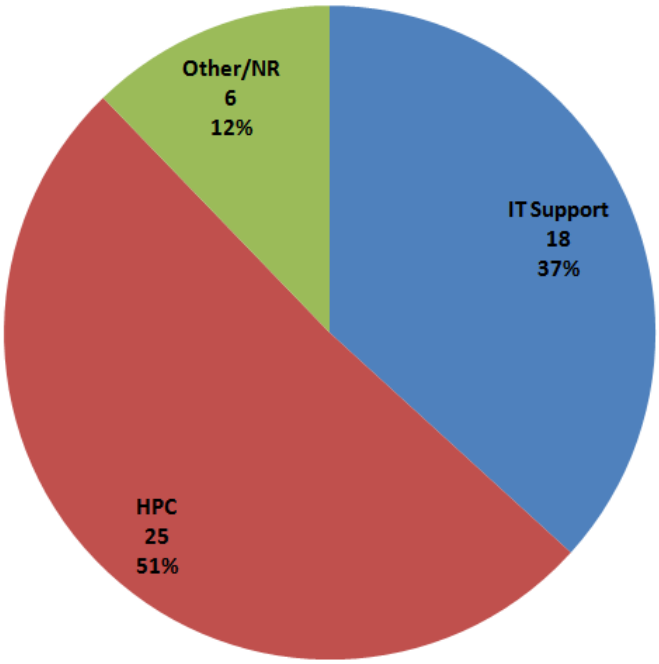
Dedicated Data Centers
"Dedicated" implies that the building's primary function is to house data center equipment. Of the data centers that replied to the survey, 21 responded that they are dedicated, and 24 responded that they are not. Four data centers did not respond to this question. The average PUE of dedicated and not dedicated data centers is 1.70 (DCIE: 0.62) and 2.32 (DCIE: 0.54), respectively.

Table 3: Relative Efficiency of Dedicated Data Centers[v]

Type	# in Category	Average Unweighted PUE	Average Unweighted DCIE	Total sq. ft.
Dedicated	21	1.70	0.62	474,674
Not Dedicated	24	2.32	0.54	176,977

Data Center Function
Of the data centers considered in this analysis, 25 reported that their primary function is high performance computing (HPC), 18 reported their primary function is IT support, and 6 responded with “other” or did not respond. The pie chart below shows the percentages of total respondents performing each function. It illustrates that nearly half of the data centers are used for HPC, while about one third are used primarily for IT support.

Figure 3: Data Center Function



The survey defined high performance computing (HPC) as a data center whose primary function is scientific computing and specified that IT support includes desktop support and data storage.

The chart below shows the frequency distribution for data centers according to their function and whether or not they are dedicated.

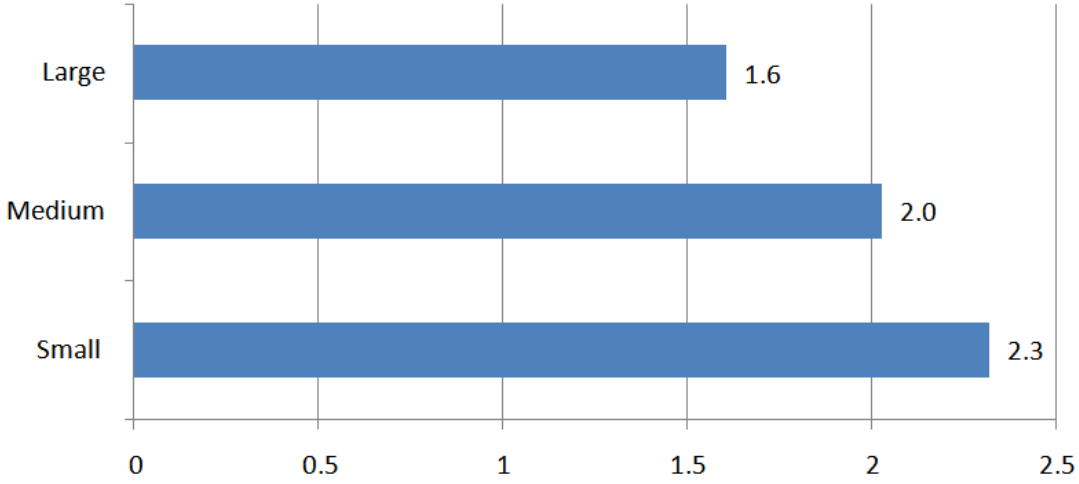
Table 4: Function of Dedicated and Not Dedicated Data Centers

	IT	HPC	Other or Function Not Reported
Dedicated	6	14	1
Not Dedicated	11	8	5
Not Reported	1	3	-

The chart suggests that it is more likely for HPC data centers to be dedicated. Of the HPC data centers, approximately 58 percent are dedicated, compared with only approximately 33 percent of IT data centers.

Data Center Square Footage
In the bar graph below, data centers are sorted into three groups according to their square footage. Data centers in the small category are below 4,499 square feet; the medium data centers are 4,500 – 15,000 square feet, and large are above 15,001 square feet. Their averages are 1,938.6 square feet, 7,622 square feet and 37,465 square feet, respectively. The graph below shows that on average the data center groups get more efficient as their square footage increases.

Figure 4: PUE by Data Center Square Footage



Moving Forward
The survey provided useful information for current consumption, and points out areas where more work is needed. FEMP will examine holes in the data, and take action to verify data and fill in missing information where possible. FEMP will also arrange two assessments of DOE data centers and produce detailed reports explaining how the assessment model can benefit other Federal data centers.

Only a small percentage of data centers surveyed had completed a DCPro assessment. In 2010, FEMP is increasing its efforts to have all data centers assessed using DC Pro. In 2010 FEMP will also schedule training sessions to train data center professionals in the benefits of DC Pro.

This survey dealt primarily with the DCIE and PUE metrics. In the 2010 additional metrics will be considered, such as server utilization percentage, rack utilization percentage and virtualization percentage.

[i] A total of 55 surveys were turned in, however 6 were omitted due to incomplete or inaccurate data.

[ii] The data centers that reported to the survey represent approximately 85 MW, or 85,000 kW, of power draw. If each data center is operated constantly and one kilowatt-hour of electricity costs $0.06, the electricity bill to operate these data centers would be over $44 million per year.

$$85{,}000\,kW \times \$0.06/kWh \times 24\,hours \times 365 days = \$44{,}676{,}000$$

With the Department of Energy spending roughly $317.5 million dollars per year on electricity, data centers could account for up to 15 percent of DOE's total energy bill.

[iii] Below are definitions of the PUE and DCIE metrics.

$$PUE = \frac{Total\ Power}{IT\ Power}$$

$$DCIE = \frac{IT\ Power}{Total\ Power}$$

[iv] The weighted average gives more importance to data centers with a greater kW draw. The simple average was computed by averaging the DCIE of each individual data center, while the weighted average DCIE was computed by dividing the average IT power across all data centers by the total power across all data centers. The formulas for each are listed below, where *n* is the number of data centers.

$$Average\ DCIE = \frac{1}{n}\sum_{1}^{n} DCIE_n$$

$$Weighted\ Average\ DCIE = \frac{\frac{1}{n}\sum_{1}^{n} IT\ Power_n}{\frac{1}{n}\sum_{1}^{n} Total\ Power_n}$$

[v] Five data centers did not specify whether or not they are dedicated. They are not included in this chart.